Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal

Section 1. General administrative information

Symptoms Of Gbt Induced In Salmon By TDGS Of The Columbia And Snake Rivers.

Bonneville project number, if an ongoing project 9300802

Business name of agency, institution or organization requesting funding
Columbia River Inter-Tribal Fish Commission

Business acronym (if appropriate) CRITFC

Proposal contact person or principal investigator:

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Subcontractors.

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NPPC Program Measure Number(s) which this project addresses.
5.6E.1

NMFS Biological Opinion Number(s) which this project addresses.
NMFS BO RPA Sec. 16 + waivers

Other planning document references.
Wy Kan Ush Me Wa Kush Wit

Subbasin.

Lower and Mid-Columbia Mainstem and Snake River Mainstem

Short description.
Study the distribution of fish in relation to total dissolved gas levels, and the resulting GBD effects on the juvenile and adult salmon of the Columbia and Snake rivers.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction		Watershed
+	Resident fish		O & M		Biodiversity/genetics
	Wildlife		Production		Population dynamics
	Oceans/estuaries	X	Research		Ecosystems
	Climate	+	Monitoring/eval.	+	Flow/survival
	Other		Resource mgmt	X	Fish disease
			Planning/admin.		Supplementation
			Enforcement		Wildlife habitat en-
			Acquisitions		hancement/restoration

Other keywords.
gas bubble disease, Total Dissolved Gas Supersaturation (TDGS)

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Measure the frequency and severity of GBT symptoms in adult salmonids as part of the adult monitoring project.		
		a	Continue to conduct sampling at the Bonneville Dam Fisheries and

			Engineering Research Laboratory
		b	Implement full sampling program at available ceremonial and subsistence fishing sites.
2	Measure the frequency and severity of GBT symptoms in in-river juvenile salmonids.		
		a	Determine the frequency and severity of GBT symptoms in the forebay and tailrace of Lower Columbia River and Snake River dams.
		b	Determine the frequency and severity of GBT symptoms in in-river juvenile salmonids at other suspected "hot spots"
3	Validate multi-factor regression tool developed from data collected and analyzed from a full scale, multi-factor experiment.		
		a	Identify and validate the horizontal and vertical distribution patterns of juvenile salmonids and determine the proportion of smolts above the depth of compensation for prevailing TDG levels in the Columbia or Snake river reservoir.
		b	Identify and validate TDGS and other physical measures along with fish distribution (a) and GBD signs (c).
		c	Identify and validate the prevelance and severity of GBD in smolts.
		d	Integrate results of this study with other multi-factor studies relating to TDGS levels, depth of fish as determined by radio tracking, occurrence of GBD in smots, and survival studies to validate the predictions from a structued regression analysis.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	5/1999	12/1999	10.00%
2	5/1999	4/2000	30.00%
3	5/1999	4/2000	60.00%
			TOTAL 100.00%

Schedule constraints.
Delays in 1998 funding could cause major schedule changes.

Completion date.
1999

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		136,700
Fringe benefits		$40,275
Supplies, materials, non-expendable property		$3,300
Operations & maintenance		$8,000
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		
PIT tags	# of tags:	
Travel		$9,523
Indirect costs		$74,768
Subcontracts	To CRRL; Personnel- $150,420; Fringe Benefits-$51,143; Supplies etc.-$31,500; con't in Other…	$377,111
Other	Oper.& Maint.; $30,606; Travel-$9,600; Indirect Costs-$103,842.	
TOTAL		$649,677

Outyear costs

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$0	$0	$0	$0
O&M as % of total	0.00%	0.00%	0.00%	0.00%

Section 6. Abstract

This is a continuation of a multi-year project, contract number 95BI39861. Spill is provided to expedite the migration of juvenile salmon past hydroelectric dams in the Columbia River basin. Under spill conditions, juvenile salmon are expected to experience less direct mortality, due to injury, than if they pass through the turbines or screened bypass systems. However, additional indirect mortality may occur during spill operations due to elevated levels of total dissolved gas supersaturation. Two key unknowns are the potential exposure to supersaturation and the proportion of fish with gas bubble trauma symptoms. The ultimate goal of this study is to determine the relation between supersaturation levels, flow rates, fish movements, fish distribution, and symptoms.

The 1999 field activities will focus on three objectives: 1) Measuring the frequency and severity of GBT symptoms in adult salmonids as part of the adult monitoring program at the Bonneville Dam Fisheries Engineering and Research Laboratory and during the tribal ceremonial and subsistence fishery. 2) Measure the frequency and severity of GBT symptoms in in-river juvenile salmonids. 3) Validate the multi-factor structural regression tool developed from data collected and analyzed from a full scale, multi-factor experiment. The results will aid in developing simulation models and will generate empirical data to test models being developed. These data will provide managers with a better picture of the actual ecological conditions fish experience and indicate potential sources of mortality. Furthermore, if the findings indicate a monitoring program is necessary, then results will provide a basis for managers to design such a program.

Section 7. Project description

a. Technical and/or scientific background.

Section 5B-29, Volume I of Wy-Kan-Ush-Mi-Wa-Kish-Wit states "Implement a program of controlled spill to achieve an 80% fish passage efficiency (fish passing by nonturbine routes), while managing spill so that dissolved gas concentrations do not exceed 125-130% daily average total dissolved gas pressure. ……. Dissolved gas monitoring measures should be implemented as a part of this program to identify physical aspects of the gas plumes in the water column and to determine the effects on fish in the river"(CRITFC, 1995.)

Section 5.6E.1. of the Columbia River Basin Fish and Wildlife Program states "Fund a study of dissolved gas supersaturation and its effects on salmon and steelhead passing through dam turbines, collection and bypass systems, spillways, adult

ladders, reservoirs and other mechanisms, particularly in connection with possible reservoir drawdowns. The study should focus on the relationship between: a)spill levels at mainstem federal projects and the resulting total dissolved gas level; and b) the symptoms of gas bubble trauma related to both lethal and non-lethal effects on juvenile and adult salmon and other aquatic species." (NPPC, 1994)

The relevance of this research to the operation of the Federal Columbia River Power System and Juvenile Transportation Program is discussed in the 1995 Biological Opinion, VIII.A.18, page 124; VIII.a.16, page 124; VIII.A.2. page 104. Section IV.A.2.d of the NMFS BIOP states " Subsequent review of the spring 1994 monitoring results by a scientific panel convened by NMFS in June, 1994, highlighted that key information is needed about the physiological effects of gas bubbles in fish and how these fish survive in the river before real-time monitoring of symptoms can be relied upon to protect fish populations. The panel recommended that this information can be obtained by carefully planned field studies and physical and biological monitoring of the river environment during spill periods. The panel concluded that signs of gas bubble trauma may be expected in salmonids inhabiting shallow water near the current water quality standard of 100% supersaturation." (NMFS, 1995)

Migratory juvenile salmon passing through the hydropower system incur high mortality. A major portion of the mortality occurs as a result of turbine passage, especially when compared to fish going over the spillways (Bevan et al. 1994). Passage survival experiments conducted by Muir et al. (1997) at Little Goose Dam in the Snake River also indicated that spill, compared to bypass or turbine passage, was the least detrimental passage route for juvenile salmonids. The NMFS Biological Opinion (NMFS 1995), the NPPC FWP (NPPC, 1995), and Nez Perce, Umatilla, Warm Springs and Yakama tribes Wy-Kan-Ush-Mi-Wa-Kish-Wit (CRITFC, 1995) plan have recommended the implementation of a spill program at the federal hydroelectric projects designed to achieve an >80% fish passage efficiency (FPE) objective. To achieve the FPE, fish can pass through a bypass system or over the spillway.

Spilling water is not without costs. As noted in the NMFS Biological Opinion in section IV.A.2.d (NMFS 1995) dissolved gas levels increase during spill as water passes over the spillway and plunges to the tailrace. As a result total dissolved gas saturation (TDGS) levels, which can rise to over 130%, often exceed the Environmental Protection Agency, Washington State Department of Ecology, and Oregon State Department of Environmental Quality maximum standard of 110% supersaturation. Controversy surrounds the potential impact of these elevated gas levels on the survival of juvenile fish (Panel 1994 and NMFS 1995). Gas bubble trauma (GBT) signs, resulting from high or prolonged exposure to supersaturated waters, have been observed in fish from the Columbia and Snake Rivers. Prior observations and laboratory studies have indicated levels above 130% are deleterious to resident fish (Dell et al. 1974, Weitkamp 1974), caged juvenile salmonids (Ebel 1969, Ebel 1971, Meekin and Turner 1974, Weitkamp 1976, Blahm et al. 1976, Dawley 1986), migrating adult salmon (Beiningen and Ebel 1970, Ebel 1971, Meekin and Allen 1974, Ebel et al. 1975, Ebel and Raymond 1976), and fish held in a laboratory (Weitkamp and Katz 1975). The impact of supersaturation greater than 110% on in-river migratory salmonids is equivocal. It is not known to what degree and how long the fish are exposed to elevated levels of dissolved gas, how the fish

may compensate by going to depth, and how dose-response physical variables and GBT are related.

Information is available on the incidence of GBT at hydropower facilities (via bypass collection), however, we are just starting to learn about the incidence of GBT on migrating salmonids in the reservoir and river system. The current monitoring program is fixed in location, sampling method, and fish passage route. This type of monitoring system has raised questions about GBT symptoms in pre-smolts (parr) residing in the reservoirs, smolts that do not pass via bypass, fish in the tailrace region of dams, and smolts at dams without bypass facilities. Thus, one primary objective of this research is to determine if the present hydroelectric monitoring program is an adequate and accurate way to monitor the prevalence and severity of GBT among migrating juvenile and adult salmonids. Recent research (Backman et al. 1998) suggest juvenile salmonids located in the forebay region of hydroelectric facilities exhibit similar GBT symptoms to fish examined at bypass facilities. However, in-river fish located in the tailrace region of hydroelectric facilities, where TDG levels are highest, appear to differ in GBT proportions when compared to bypass examined smolts.

This project is needed to insure that the benefits of spill (i.e., achieving a 80% FPE) are not compromised by potentially lethal TDG levels. Research and monitoring provides fishery managers, researchers, and hydropower system operators information on the distribution and incidence of juvenile and adult salmonids effected by GBT. It provides data on the range of conditions needed for controlled laboratory studies, data to develop simulation model parameters, and data to test models.

Work of key project personnel in relation to any past or current work similar to the proposal can be seen in the attached resumes.

b. Proposal objectives.

Objective 1: Measure the frequency and severity of GBT symptoms in adult salmonids as part of the adult monitoring project.

a.) Continue to conduct sampling at the Bonneville Dam Fisheries and Engineering Research Laboratory.

b.) Implement full sampling program at available ceremonial and subsistence fishing sites.

Hypothesis and assumptions necessary to test these

Hypothesis 1.) Adults sampled at the hydroelectric facilities are representative of in-river adult populations.

Hypothesis 2.) Controlled spill does not increase prevalence of GBT in adults.

Assumptions: Sufficient sample sizes can be obtained.

Based on frequency and severity of GBT symptoms, detrimental effects,or lack of, could be assessed and thus influence management decisions about hydro-power operations (e.g., spill, transportation).

Sub-lethal and lethal supersaturation levels are a concern for adult salmon as well as juvenile salmon. To address these concerns, GBT adult monitoring will be conducted at the Fisheries Engineering Research Laboratory at Bonneville Dam. Validation for adults examined at the dam, similar to juveniles, is needed to confirm that adult salmonids traveling through hydroelectric facilities are representative of in-river adult populations. Sampling from the tribal fishery (ceremonial and subsistence) will allow for the monitoring of the in-river condition of adults and provide a potential validation method for examinations at hydroelectric facilities.

Objective 2: Measure the frequency and severity of GBT symptoms in in-river juvenile salmonids.

a.) Monitor the frequency and severity of GBT symptoms in the forebay and tailrace of Lower Columbia River Dams.

b.) Measure the frequency and severity of GBT symptoms in in-river juvenile salmonids at other suspected "hot spots"

Hypothesis and assumptions necessary to test these

Hypothesis 1.) Juveniles sampled at the hydroelectric facilities are representative of in-river juvenile populations.

Hypothesis 2.) Controlled spill does not increase prevalence of GBT in juveniles.

Assumptions: Sufficient sample sizes can be obtained
Samples caught in-river are representative of total in-river population
Based on frequency and severity of GBT symptoms, detrimental effects,or lack of, could be assessed and thus influence management decisions about hydro-power operations (e.g., spill, transportation).

Studying the effects of gas bubble trauma on juvenile salmonids as they pass from the forebay, through the dam, and into the tailrace will identify the overall effects that dams impose on salmon in relation to GBT. This may help to further identify appropriate spill levels and allowable TDGS levels.

In investigating suspected “hot spots” certain river reaches or locations that can’t be assessed under the current SMP program could be assessed by mobile in-river studies. This could help in further identifying river reaches in which %TDGS can pose a threat to migrating salmonids.

Objective 3: Validate multi-factor regression tool developed from data collected and analyzed from prior full scale, multi-factor experiment.

a.) Identify and validate the horizontal and vertical distribution patterns of juvenile salmonids and determine the proportion of smolts above the depth of compesnation for prevailing TDG levels in Columbia or Snake river reservoirs.

b.) Identify and validate TDGS and other physical measures along with fish distribution (a) and GBD signs (c).

c.) Identify and validate the prevelance and severity of GBD in smolts.

d.) Integrate results of this study with other multi-factor studies relating to TDGS levels, depth of fish as determined by radio tracking, occurrence of GBD in smolts, and survival studies to validate regression model.

Hypothesis and assumptions necessary to test these

Hypothesis 1: Structured regression tool predicts prevalence and severity of GBD signs in juvenile salmonids.

Assumptions: Structured regression tool will have been developed.

Through the use of data collected from hydroacoustic surveys, in-river monitoring, and current and prior research efforts, a multi-factor regression tool will be developed to better assess prevalence and severity of GBT in fish. In-river research will be used to validate the predicted GBT occurrence as well as the current Smolt Monitoring Program. Hydroacoustic studies will be used to validate the multi-factor regression tool. TDGS data will be used to validate model predicted gas levels. By defining fish distribution, as well as predicted gas levels we can estimate the predicted gas exposure. Through prior, present and future laboratory studies we can attempt to quantify how predicted gas exposures would affect GBT symptom prevalence and how GBT relates to mortality. Currently both the Columbia River Research Laboratory and CRITFC are consolidating data and undertaking this modeling effort. Preliminary results are expected in April 1998.

c. Rationale and significance to Regional Programs.

Project 9300802 specifically addresses Section 5.6E.1 of the FWP (see section 7a). This project particularly focuses on TDGS and its effect on salmonids before, during, and after passing through dam turbines, collection and bypass systems, and spillways. By collecting samples in the forebay, at the bypass facilities, and in the tailrace of a hydroelectric facility we can gain insight to the relationships between TDGS and its effect on migrating juvenile salmonids as they pass through the dam. To a lesser extent, this project also examines TDGS levels, resulting from spill, by collecting comprehensive data using a variety of gas meters located throughout the area of study. This allowed for comprehensive data analysis concerning the physical properties of TDGS in the reservoir.

Relevant projects

Columbia River Research Laboratory

-Depth tag studies to identify the depth at which salmonids migrate. This is important in estimating the number of smolts at risk due to TDG levels near the surface.

U.S. Army Corp of Engineers

- TDGS monitoring at hydroelectric facilities. This is important in estimating the levels of TDGS that migrating salmonids have been exposed to.

Fish Passage Center

- The Smolt monitoring program. The SMP is the primary tool used in assessing the prevalence of GBT in migrating juvenile salmonids and therefore should be validated via in-river studies.

d. Project history

Project No. 9300802 is an ongoing project that has been in operation since 1995. Three annual technical reports (1995, 1996, 1997) have been submitted to BPA titled **Symptoms of Gas Bubble Trauma induced in salmon (*Oncorhynchus spp*.) by total dissolved gas supersaturation of the Snake and Columbia Rivers, USA**(Backman et al. 1997). A fourth report, the 1998 technical report, will be submitted in late January, 1998. Costs since 1995 were as follows:

Project Year	**Project Cost**
1995	$153,378
1996	$505,794
1997	$664,627
Total	**$1,323,799**

The hydroacoustic portion (CRRL) of this investigation was previously funded by the U.S. Army Corps of Engineers.

Summary of major results achieved:

During the 1997 spill program, juvenile fish were sampled with purse seines, beach seines, and trawls in two primary and three secondary river reaches of the Columbia and Snake rivers to determine the frequency and severity of GBT symptoms. Approximately 2.8% of fish examined from in the river (in-river) exhibited symptoms of GBT and 6.6% of the fish examined at the bypass facilities exhibited symptoms of GBT using data collected from concurrent in-river sampling weeks in 1997. Symptom prevalence peaked at 19% incidence in Lower Monumental reservoir during periods of uncontrolled spill when TDGS exceeded 130%. Symptom prevalence averaged 2.2% during all in-river sampling. Adult salmonids were also examined for symptoms at Bonneville Dam and at ceremonial and subsistence (C&S) fishing sites. Adult salmonids at Bonneville Dam exhibited symptoms in 6.4% of the total sample in 1997. Adult salmonids examined at C&S fishing sites exhibited no signs of GBT, although fish were not observed during periods of high (>125%) TDGS in 1997.

Preliminary studies examining symptom prevalence in forebay and tailrace samples at McNary dam indicated 1% symptom prevalence in the forebay and 5.5% symptom prevalence in the tailrace when sampling was conducted on concurrent sampling days.

e. Methods.

The following is a summary of the methodology used in the operation of this project. A detailed description of the methodology can be read in the 1997 Annual

Report to BPA (Backman et al. 1998)/and the 1998 annual report to the USCOE (Rondorf and Feil 1997)

Objective 1: Measure the frequency and severity of GBT symptoms in adult salmonids as part of the adult monitoring project.

Sampling sites: Adult chinook, sockeye, and steelhead will be sampled and examined for signs of gas bubble trauma, at the Bonneville Dam Fisheries Engineering Research Laboratory.

Columbia River adult salmonids, harvested during the tribal C&S fishery, will be also examined for symptoms of GBT. Sampling sites will be conducted near The Dalles Dam , Cascade Locks, Klickitat river and John Day Dam.

Examination procedures: Adults examined at Bonneville will be placed in a 380-*l* sampling tank, which will be filled with fresh river water at the start of each sampling period. Fish will then be anesthetized with a buffered Tricane Methane Sulfonate (MS-222) solution and carefully examined for external symptoms using a 2.5X headband binocular magnifier. Included in the examination procedure will be the observation for external symptoms such as distended eyes and/or the presence of emboli within the mouth, on the operculum, or between fin rays (Beiningen and Ebel 1970). The degree of affect in each specific region will be ranked 1-4 according to the percent of the area covered (see methods for juvenile examination). Individual examinations take approximately 30 s. Following the inspection, fish will be allowed to recover in freshwater and released.

C&S caught fish will be examined using the same protocol described for sampling at Bonneville Dam except an 8x handheld binocular magnifier will be used and the fish will not need to be anesthetized since they will have been subdued (euthenized) by the fisher. Fish that are in the nets for an unknown period of time and are dead upon removal are not sampled.

Statistical procedures used in adult analysis:

TDG Measurements (Bonneville): Daily mean percent TDGS measurements from three stations below Bonneville Dam will be obtained from the FPC weekly dissolved gas summaries.

Observations of GBT will be reported as a percentage of the day's sample size, and compared against the 24-hour mean %TDGS measurements at each of three different monitoring stations.

Objective 2: Measure the frequency and severity of GBT symptoms in in-river juvenile salmonids.

Sampling sites: We will monitor the frequency and severity of GBT symptoms in the forebay and tailrace of Lower Columbia River Dams as well as other suspected "hot spots within the Columbia and Snake rivers.

Sampling Methods:

Purse seine sampling: A purse seine, approximately 130-m in length and 10-m in depth with a 2.5-cm stretch mesh, will be deployed off the deck of a 24-ft boat with the assistance of another 20-ft boat. The portion of the net containing the trapped fish will be allowed to stay in the river while the fish are retrieved with a sanctuary dip net and placed in a 190-*l* live box filled with circulating river water. Captured fish will then be transferred to the mobile fish lab and examined. The time the net was set, the time the net was pulled, location (R.K. and G.P.S.), and depth will recorded for each set.

Beach seine sampling: A beach seine, approximately 30-m in length and 2-m in depth with a 2.5-cm stretch mesh, will be deployed off the deck of an 18-ft boat. The portion of the net containing the trapped fish will be allowed to stay in the river while the fish are retrieved with a sanctuary dip net and placed in a 190-*l* live box filled with fresh river water. Captured fish will then be transferred to the mobile fish lab.

Trawl net sampling: A rectangular 7-m by 3-m trawl with 2-cm stretch mesh will pulled with a 24-ft boat. Fish will be collected from a sanctuary container located at the cod end of the trawl. This configuration will allow the sanctuary container to hold fish in water as it is brought aboard. The fish will then be transferred with a sanctuary dip net to the live box full of river water and brought to the examination station.

Juvenile Examination procedures

Once collected, fish will be transferred from the boat to a mobile examination station in 45-*l* plastic buckets. Approximately 5-10 fish will then be transferred to an 8-*l* plastic bucket containing a buffered MS-222 solution (approximately 80 ppm) and held until they can be examined by trained personnel. During examination, the fish will be held in a wet tray. Fish will always be held in water and transferred quickly between buckets of water in soft nets. Smolts will be passed by a Passive Integrated Transponder (PIT) tag detector prior to examination.

Examination procedures will follow the protocol of the Smolt Monitoring Project. Data will be recorded on field data sheets and entered into to a computer spreadsheet data file. Spreadsheet data will be cross-checked with field data to correct and validate the computer data.

All biological staff will be trained in symptom examination techniques developed at the CRRL, Cook WA. Quality control measures of field procedures will be implemented to insure correct and consistent data collection among biologists.

Statistical procedures used in juvenile analysis:

Sample size determination: To estimate the sample size required to determine the percentage of the population with symptoms (assuming a population of infinite size) we followed the procedure developed by John Beeman at CRRL as part of the Smolt Monitoring Program of the Fish Passage Center. This method was derived from

Snedecor and Cochran (1980). Simulation suggests a sample of 40 fish will provide an estimate of symptom prevalence of ± 9.4% when $P = 0.1$, and ± 15.6 % when $P = 0.5$. Increasing the sample size to n = 100 increases the precision, resulting in confidence intervals of ± 6 and ± 10% respectively. In other words, if we detect a 10% symptom prevalence, at $P=0.1$ and a sample size of $\geq$ 100 fish, we can conclude that between 4% and 16% of the actual in-river population has symptoms.

TDG measurements: The Single Factor Analysis of Variance (ANOVA) test was used to statistically compare 24 hour average TDGS measurements. ANOVA comparisons will be performed on statistical weeks (Saturday to Sunday) on both the Oregon and Washington sides of the river. Focus, however will be placed on those weeks in which gas bubble trauma symptoms are found on in-river and/or bypass sampled juvenile salmonids. Results from this analysis will enable us to identify statistical variation, or the lack of, in mean TDGS per week in the reach of the Columbia River where in-river and bypass smolts were sampled.

Objective 3: Validate multi-factor regression tool developed from data collected and analyzed from a full scale, multi-factor experiment.

Methods for collecting Hydroacoustic data : Vertical and horizontal distribution of fish will be assessed along transects at index sites with a mobile hydroacoustic system. We propose to use a remotely operated vehicle (ROV) to deploy an up-looking hydroacoustic transducer to characterize near surface fish distribution and a towed body to deploy a down-looking hydroacoustic transducer to describe the distribution below the compensation depth. This configuration eliminates a tow cable that might scare fish if a towed body was used to deploy the up looking transducer. This deployment configuration results in mostly dorsal or ventral aspects of esonified fish targets. The ROV and towed body will be deployed and controlled from a boat. The ROV has a tether between the ROV and the boat and the towed body is suspended using wire rope. The boat will be located using a real time differentially corrected Global Positioning System (GPS) and the ROV will be located using a pinger locating system. Fixed-aspect point sampling may be used at locations where reservoir morphology prohibits mobile sampling such as near shore areas. The depth of the individual fish targets will be available from the hydroacoustic system and the latitude and longitude will be available from a GPS. All hydroacoustic data will be analyzed using echo counting techniques (Thorne 1983). Mobile hydroacoustic surveys will be conducted concurrently with the measurement of TDG levels, depth-sensitive radio telemetry (Maule et al. 1996), and with the assessment of occurrence of GBT. Each hydroacoustic survey will be comprised of repeated sampling over several 24-h periods along transects at a pre-selected index site. Data on environmental variables at the study site including light, wind speed, water temperature, turbidity, water velocities, and TDG levels at selected cross sections in McNary Reservoir will be collected. The empirical data on water velocities and TDG levels collected at index sites will provide an opportunity for validation of predicted results of water velocity and TDG. Furthermore, we recognize the need to describe TDG levels at the fish sample site because of spatial and temporal patterns of TDG. Experience by the Corp of Engineers (COE) indicates the dynamics of TDG levels are

best characterized by an array of fixed wireless gas meters. We will use 3 sets of submerged (15 ft) dissolved gas meters with 3 meters in each set. Each set will be deployed with one meter in the middle of a cross section and one on each side of the reservoir consistent with earlier COE monitoring in McNary Reservoir. Surveys will be conducted on a weekly basis or in three 10-d time blocks from 1 April to 1 June 1999 with specific schedules being partially dependent on hydropower operating conditions and prevailing weather conditions. We will estimate the mean fish density (fish/10,000 m^3 of water) in the water ensonified by the hydroacoustic system along 10 m segments of each transect at 0.5 m depth strata.

Mean fish densities in selected depth strata will be compared using analysis of variance (ANOVA) to determine if fish densities differ significantly between depth strata and/or between index study sites. Regression analysis will be conducted to identify environmental variables that may be determinants of fish density at the index sites. Estimated horizontal fish densities will be reported as the number of fish per square unit area basis. Densities above and below the depth of compensation will be presented in an aerial or plan view. A kriging technique will be used to estimate the error about the surface describing fish density from an aerial perspective (Sullivan 1991; Cressie 1991).

GBD signs and species composition: This will follow the methods of purse seining, trawling, and beach seining outlined above and described in detail in Backman et al. (1998) for sampling juvenile salmon. Surveys will be conducted on a weekly basis or in three 10-d time blocks from 1 April to 1 June 1999 with specific schedules being partially dependent on hydropower operating conditions and prevailing weather conditions. Specific schedules will be partially dependent on hydropower operating conditions and prevailing weather conditions and presence of fish. This will be conducted concurrently with the hydroacoustic studies.

Multi-factor regression model validation: There are three opportunities to validate the predicted model results with empirical data collected from this study. First, users and reviewers of the Gastrans-2D will be able to simulate reservoir-wide TDG levels and compare predicted TDG levels to empirical data collected concurrently with fish distribution data in this study. Second, model users will be able to compare predicted flow with TDG levels and fish distributions. Third, predicted distribution from a multi-regression model will be validated by comparing empirical fish distribution data collected by this study.

Assessment of factors that may limit success of project: The transportation of juvenile fish could hamper our ability to collect sufficient sample sizes. Low spill levels, and therefore low TDGS levels, could limit our ability to sample smolts exposed to elevated gas levels. Weather and river conditions can also limit our ability to conduct sampling. Lastly because of the multi-analytical nature of this project, lack of funding to projects collaborating and correlating with this study could impede the overall progress of this research.

f. Facilities and equipment.

This project is an ongoing project and therefore is well established in regards to field equipment. The following is a list of major equipment used in the operation of this project. This an existing inventory list of major equipment that has been obtained or leased since the start of this project.

ITEM	COMMENTS
Minivan	Transport work crew
Suburban	Transport equipment, haul boats
Dually Truck	Transport nets, haul boat
Pickup Truck	Transport nets/equipment, haul boats
25' Munson Hammerhead jet engine boat	Conducts sampling operations
27' Research Boat(CRRL)	CRRL hydroacoustic boat
22' Imperial boat, outboard	Assists in sampling operations
Remote Operation Vehicle(CRRL)	Used to deploy hydroacoustic transducers in up-looking direction.
Acoustic Doppler current profiler(CRRL)	Measures water velocities during the mobile hydroacoustic surveys
HYDROLAB Surveyor 4	Water quality sampling
COMMON SENSING Total dissolved gas monitor Model TBO-L	Water quality sampling
YSI DISSOLVED OXYGEN METER model 55/50 ft sn:	Water quality sampling
LEICA MICROSCOPES Model MZ-6	Fish examinations
NCL 150 POWER FOR SCOPES	Accessories for Microscopes
CAMERA with telescoping lens	Used to document incidences of GBT
COLEMAN POWERMATE GENERATOR	Supplies power for mobile lab
GARMIN GPS 45 Personal Navigator	Documents sampling locations
EAGLE MAGNA 3 FISH FINDER& TRANSDUCER	Locates fish and identifies depth
SONAR & HARNESS	Locates fish and identifies depth
Beach seine	Samples fish
Purse seine	Samples fish
Trawl	Samples fish
Compaq 1075 Laptop Computer	Data analysis and project operation
Compaq 8772 Desktop Computer	Data analysis and project operation

Facilities to be used are limited to the Bonneville Dam Fisheries Engineering Research Laboratory. This facility is used for the examination of adult salmonids.

g. References.

Backman W.H., A.F. Evans. and M.A. Hawbecker. 1998. Symptoms of Gas Bubble Trauma induced in salmon (Oncorhynchus spp.) by total dissolved gas supersaturation of the Snake and Columbia Rivers, USA. 1998 Annual Report. 95BI39861, Bonneville Power Administration, Portland, OR.

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Section 8. Relationships to other projects

Columbia River Research Laboratory

- Hydroacoustic studies to assess the vertical and horizontal distribution of juvenile salmonids. This will help identify how fish are distributed throughout the reservoir and estimate the number of smolts at risk (above the compensation level, see Note) due to TDG levels near the surface. Note: It is estimated that every meter of depth can compensate for approximately 10% TDGS.

-Depth tag studies to identify the depth at which salmonids migrate. This is important in estimating the number of smolts at risk due to TDG levels near the surface.

U.S. Army Corp of Engineers

- TDGS monitoring at hydroelectric facilities. This is important in estimating the levels of TDGS that migrating salmonids have been exposed to.

Fish Passage Center

- The Smolt monitoring program. The SMP is the primary tool used in assessing the prevalence of GBT in migrating juvenile salmonids and therefore should be validated via in-river studies.

Analysis of these complex data sets between the agencies has just begun. We anticipate that this information base will be applied to the development of multiple regression relationships among the variables and exposure/symptom scenarios. This analysis could be used to guide present and future laboratory studies and will be able to help assess the

multi factor data needs of 1998. Interagency cooperation will be of the utmost importance in ensuring that a common data set is developed. Overall, such data could be important in estimating the significance of depth compensation, exposure time and the role it plays in the prevalence and severity of GBT symptoms.

Section 9. Key personnel

Dr. Thomas W.H. Backman

PRINCIPLE INVESTIGATOR AND PROJECT MANAGER: Senior Fishery Scientist
FTE: 1

EDUCATION:

B.Sc. and M.Sc. in Marine Biology, San Diego State University.
Ph.D. in Fisheries, University of Washington.

CURRENT EMPLOYMENT:

Columbia River Inter-Tribal Fish Commission
729 N. E. Oregon, Suite 200
Portland, OR. 97232

Dr. Backman has been a Senior Fishery Scientist with the Commission since 1991. During that time he as served as the President of the Oregon Chapter of the American Fisheries Society, a member of the NMFS Expert Panel of Gas Bubble Trauma, and a member of the NMFS/EPA gas bubble team. Dr. Backman provides scientific expertise on salmon recovery issues by conducting research, developing scientific papers and analyses, participation in workshops, formulating recovery strategies, and providing expert testimony.

Prior to CRITFC, Dr. Backman was a Fishery Biologist (GS-13) with the U.S. Fish and Wildlife Service (FWS). His duties with FWS were: Administrated and participated in technical groups for the U.S. Fish and Wildlife Service under the Emergency Stripped Bass Act. Administrated the Andramous Grants Program. Conducted laboratory and field research on American Shad. Dr. Backman's graduate research (NSF funded) focused on fish habitat related research, including quantitative genetics research and development of habitat restoration technology for depleted and damaged submerged aquatic vegetation.

Backman W.H., A.F. Evans. and M.A. Hawbecker. 1998. Symptoms of Gas Bubble Trauma induced in salmon (Oncorhynchus spp.) by total dissolved gas supersaturation of the Snake and Columbia Rivers, USA. 1998 Annual Report. 95BI39861, Bonneville Power Administration, Portland, OR.

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Dennis W. Rondorf - Fishery Research Biologist

FTE: .25

EDUCATION:

M.S. Oceanography and Limnology, University of Wisconsin, Madison, 1981
B.S. Wildlife Management, University of Minnesota, St. Paul, 1972

CURRENT EMPLOYMENT AND RESPONSIBILITIES:

D.W. Rondorf serves as a Fishery Research Biologist and Section Leader for the Anadromous Fish Ecology section at the Columbia River Research Laboratory, Biological Resources Division, U.S. Geological Survey, Cook, Washington. Current areas of research include the behavior and ecology of Snake River wild and hatchery fall chinook salmon, the distribution of smolts and relation to gas supersaturation in the main stem Columbia River, and behavior of smolts to evaluate a prototype surface collector at Lower Granite Dam, Washington. In recent years, D.W. Rondorf has lead research teams using radio telemetry, geographic information systems (GIS), global positioning systems (GPS), remotely operated underwater vehicles (ROV), hydroacoustic fish stock assessment systems, and acoustic Doppler current profilers (ADCP) as research tools. Between 1979 and 1997, D.W. Rondorf was employed by the research division of the U.S. Fish and Wildlife Service and the National Biological Service to conduct research on juvenile salmon in the Columbia River basin.

Adams, N.S., D.W. Rondorf, S.D. Evans, J.E. Kelley, and R.W. Perry. 1998. Effects of surgically and gastrically implanted radio transmitters on swimming performance and predator avoidance of juvenile chinook salmon. (*In Press*) Canadian Journal of Fisheries and Aquatic Sciences.

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Parsley, M.J., D.W. Rondorf, and M.E. Hanks. 1998. Remote sensing of fish and their habitats. Proceedings of instream and environmental flows symposium-technology

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Michael A. Hawbecker

FISHERIES BIOLOGIST
FTE-1

EDUCATION

B.S. in Environmental Biology, Eastern Illinois University.
Additional Course Work: Intro to Geographical Information Systems, PSU, Fall 1997; Intro to Visual Basic, PCC, Winter 1998

CURRENT EMPLOYMENT:

Columbia River Inter-Tribal Fish Commission
729 N. E. Oregon, Suite 200
Portland, OR. 97232

Mike has 4+ years of experience working with salmon in the Pacific Northwest. Mike has been a biologist with the Columbia River Inter-Tribal Fish Commission for 3 years and has worked on the Gas Bubble Trauma project for each of those 3 years. Prior to working for CRITFC Mike was employed at the U.S.G.S. ,Columbia River Research Laboratory in Cook, WA and at the U.S.G.S., Marrowstone Field Station in Nordland, WA.

Present job duties include; the co-management of office and field activities; responsibility for data collection and analysis; field sampling operations (fish examinations, purse seine and trawl operation, use of scientific equipment, boat modification and gear preparation; supervision of field activities in absence of Senior Fish Scientist; preparation of multimedia presentations; maintenance, operation and organization of project network, files & folders; project budgeting; preparation of Statement of Work reports to BPA; seasonal employee hiring, management, and supervision; technical report writing.

Backman W.H., A.F. Evans. and M.A. Hawbecker. 1998. Symptoms of Gas Bubble Trauma induced in salmon (Oncorhynchus spp.) by total dissolved gas supersaturation of the Snake and Columbia Rivers, USA. 1998 Annual Report. 95BI39861, Bonneville Power Administration, Portland, OR.

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Allen F. Evans

FISHERIES BIOLOGIST
FTE:1

EDUCATION

B.A., Biology, The College of Wooster, Wooster, Ohio. May 1995.

Rhodes University, Grahamstown, South Africa. May – August 1994. Attended graduate fisheries classes and conducted research for the fisheries department.

CURRENT EMPLOYMENT:

Columbia River Inter-Tribal Fish Commission
729 N. E. Oregon, Suite 200
Portland, OR. 97232

Allen has 4+ years of experience working with salmon. Allen has been a biologist with the Columbia River Inter-Tribal Fish Commission for 3 years and has worked on the Gas Bubble Trauma project for each of those 3 years. Prior to working for CRITFC Allen was employed at the U.S.G.S., Biological Resources Division, Seattle, WA and at the Department of Ichthyology, Rhodes University, Grahamstown, South Africa.

Allen has, and will maintain, the following responsibilities: Manage database, graphic programs, statistical programs and other computer oriented skills. Serves as field biologist by sampling and examining salmonids for signs of Gas Bubble Trauma. Supervise field technicians. Responsible for the completion of all field research objects. Analyze, synthesize and prepare data for technical reports, publications and seminars. Produce technical papers and give scientific presentations. Maintain scientific sampling permits (ESA etc…) and coordinate research needs with other agencies.

Backman W.H., A.F. Evans. and M.A. Hawbecker. 1998. Symptoms of Gas Bubble Trauma induced in salmon (Oncorhynchus spp.) by total dissolved gas supersaturation of the Snake and Columbia Rivers, USA. 1998 Annual Report. 95BI39861, Bonneville Power Administration, Portland, OR.

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Davies M.T. and A.F Evans. The possible Significance of Egg Size on the Growth and Survival of Post-hatched *Oncorhynchus mykiss* fry. Bylde Aquaculture Spring, 1996.

Section 10. Information/technology transfer

The technology transfer will be accomplished through oral presentations, technical reports, and publications. Managers will use the results of this project, as well as other biological studies, to evaluate the physical modifications at the dams and various management scenarios used to reduce TDG levels. The uncertainty associated with data collected by the Smolt Monitoring Program will also be reduced. This will facilitate a review by state environmental agencies and determine the possibility of TDGS waivers for the mainstem Columbia and Snake rivers. In addition, the Dissolved Gas Team, state and federal fisheries agencies, Indian Tribes, and other interested parties will be able to reassess the meaning of the observed occurrence of GBD with an adequate knowledge of the distribution of juvenile salmonids in reservoirs.